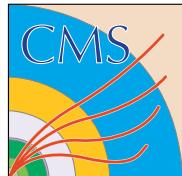


**PRS: Physics Reconstruction and Selection
HCAL/JetsMET group**

HCAL/JetMET Status

**Shuichi Kunori
U. of Maryland
18-Feb-2002**

<http://computing.fnal.gov/cms/jpg/Default.htm>



Activities present and near future

Simulation

- Geometry in CMSIM/OSCAR.
- Verify CMSIM/OSCAR.
- Verify hadron shower physics in G4.

past
present
future

Calibration & Monitoring

- Data definition for Calibration Database
- HF/HB/HE (HO) Calibration scenario
- In-situ calibration ($\gamma/Z0$ -jet balancing / $M(jj)$ for W from top/...)
- Improvement of energy scale (+ resolution) [20GeV-TeV]

ORCA code

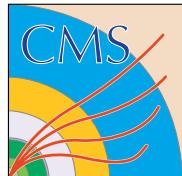
- Readout simulation / Jet finder / MET code / ntuple maker

Physics Objects (τ jet, jets, MET)

- L1 verification / HLT algorithm and rates / Trigger table
- New algorithms/Pile-up suppression/...

Physics Analysis

- Dijet / Single top / ttH / qqH, $H \rightarrow \tau\tau, WW$, invisible / SUSY / ...



Simulation group

(Sunanda Banerjee)

Full simulation

- CMSIM/OSCAR implementation
 - Geometry (Sunanda Banerjee)
 - Photon production & propagation (???)
 - From tile to HPD
 - HF shower library (Victor Kolosov)
- Verification
 - Tool - Standard histograms (Shashi Dugad)
 - Basic / advanced
 - Hadron Shower (Sudeshna Banerjee)

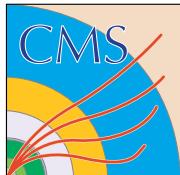
Fast simulation

- Calorimeter response (???, Salavat, Pal)
- Physics objects – jets/met/tau (???)

Test beam simulation

- H2 PPP / Production wedges (Kajari Mazumdar)
- Hanging file

Simulation software/production support



Calibration & Monitoring Group

- Olga Kodolova -

Energy scale of HCAL channels

- ADC → GeV
 - Equal response to single particle

Energy scale of Jets

- GeV (in calibrated ECAL and HCAL readout channels) → GeV (particle level jets)
- Equal response to mixture of γ/e 's and hadrons
 - Correction to non-linear calorimeter response to hadrons
 - Correction to non-uniform response at HB/HE/HF boundary
- Work closely to Physics Object group

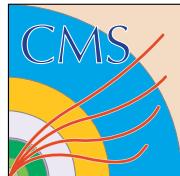
Monitoring

- Radiation damage & dead/sick channels

Calibration database

- Interface software & bookkeeping

Synchronization



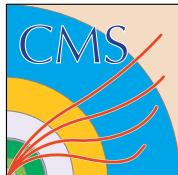
HLT Jets and Energy Corrections

Two steps for HLT jets

- 1) Find jets with $R=0.5 - 1.0$ with fixed calorimeter weights.
- 2) Correct energy scale to sharpen turn on curve.

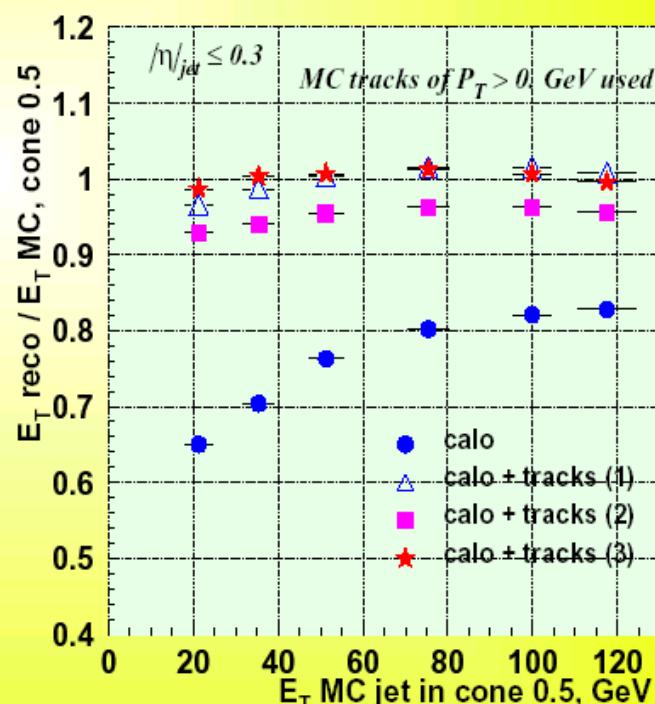
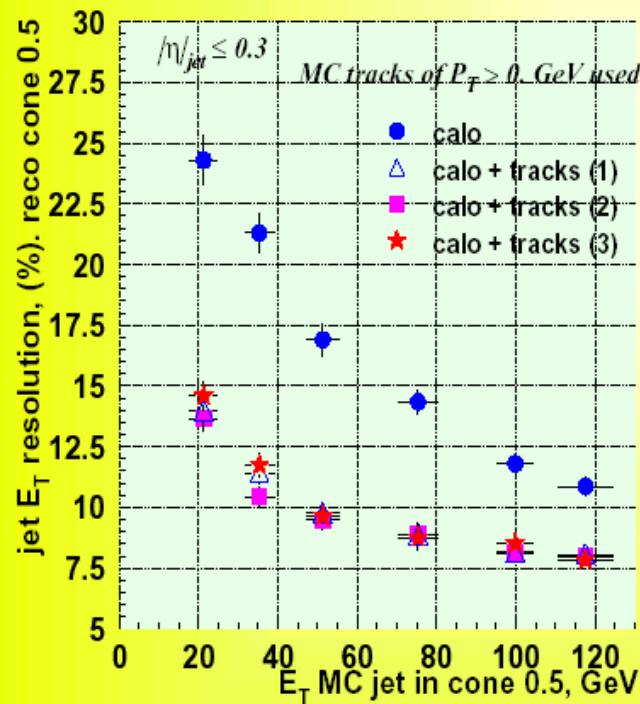
Energy Correction

- **Jet based**
 - 1) $E = a \times (EC + HC)$, a depends on jet(ET, η) **baseline**
 - 2) $E = a \times EC + b \times HC$, a, b depend on jet(ET, η)
- **Cluster based**
 - 3) $E = em + had$ (requires to separate em/had clusters)
 $em = a \times EC$ for e/ γ
 $had = b \times EC + c \times HC$, for had. b (c) depend on EC (HC)
- **Use of reconstructed tracks**
 - 4) $E = E_0 + (\text{Tracks swept away by } 4T \text{ field})$
 - 5) $E = EC(e/\gamma + \text{neutral.h}) + HC(\text{neutral.h}) + \text{Tracks(charged.h)}$

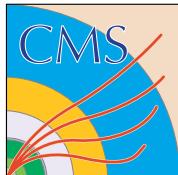


Jet Energy Correction #5 Resolution & Linearity

Window algorithm and algorithm with tracker information. Three options are used for calculating expected response: **e/ π technique (calo+tracks(1))**, **library of responses (calo+tracks (2))**, **matched clusters+library of responses (calo+tracks(3))**



(Irina, Olga + Sasha, Dan)



Calibration - Tools

A) Megatile scanner:

- Collimated Co⁶⁰ gamma source
- each tile: light yield
- during construction
all tiles

B) Moving radio active source:

- Co⁶⁰ gamma source
- full chain: gain
- during CMS-open (manual)
all tiles
- during off beam time (remote)
tiles in layer 0 & 9

C) UV Laser:

- full chain: timing, gain-change
- during off beam time
tiles in layer 0 & 9
all RBX

D) Blue LED:

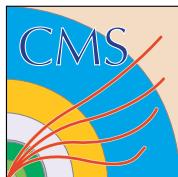
- timing, gain change
- during the off beam time
all RBX

E) Test beam

- normalization between
GeV vs. ADC vs. A,B,C,D
- ratios: elec/pion, muon/pion
- pulse shape/time structure
- before assembly
a few wedges

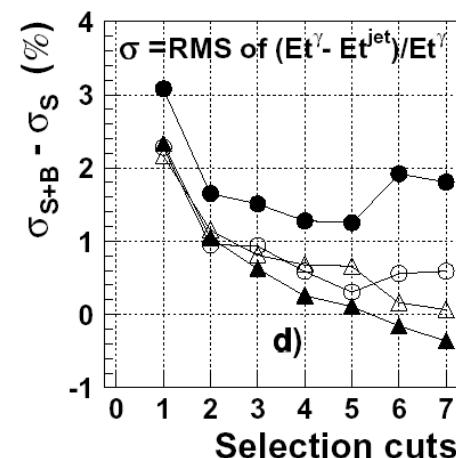
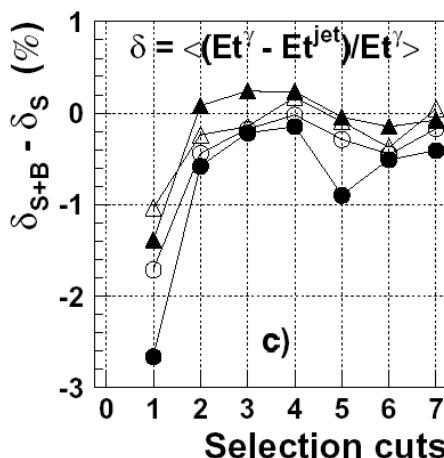
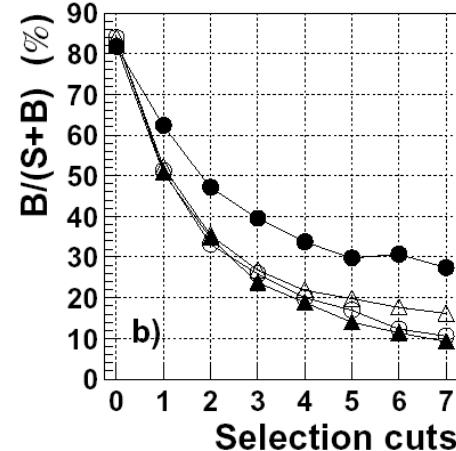
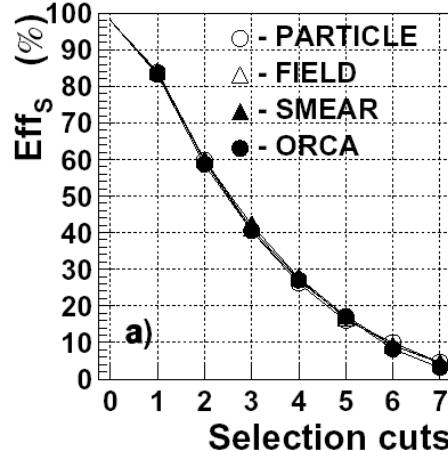
F) Physics events

- mip signal, link to HO
muon
- calo energy scale (e/pi)
charged hadron
- physics energy scale
photon+jet balancing
Z+jet balancing
di-jets balancing
di-jet mass
W->jj in top decay
- >> non-linear response
- >> pile-up effect

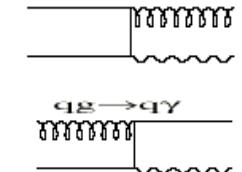


γ -jet: background and errors

Case $40 < Et^\gamma < 100 GeV$.



(Konoplianikov/Kodolova)



We have at ORCA-level for $Et^\gamma = 100 GeV$:

Selection cuts	1 ($\text{Eff}_S=83\%$)	...	7 ($\text{Eff}_S=5\%$)
Et_γ^{isol} max (GeV)	12	...	4
$(180^\circ - \Delta\phi^\circ)$ max	38	...	15
$Et^{\text{jet}2}$ max (GeV)	40	...	15
Et^{out} max (GeV)	41	...	10

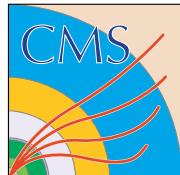
Et_γ^{isol} – summarized Et in the $R=0.7$ outside 3×3 crystals,

$\Delta\phi$ – angle between " γ " and jet

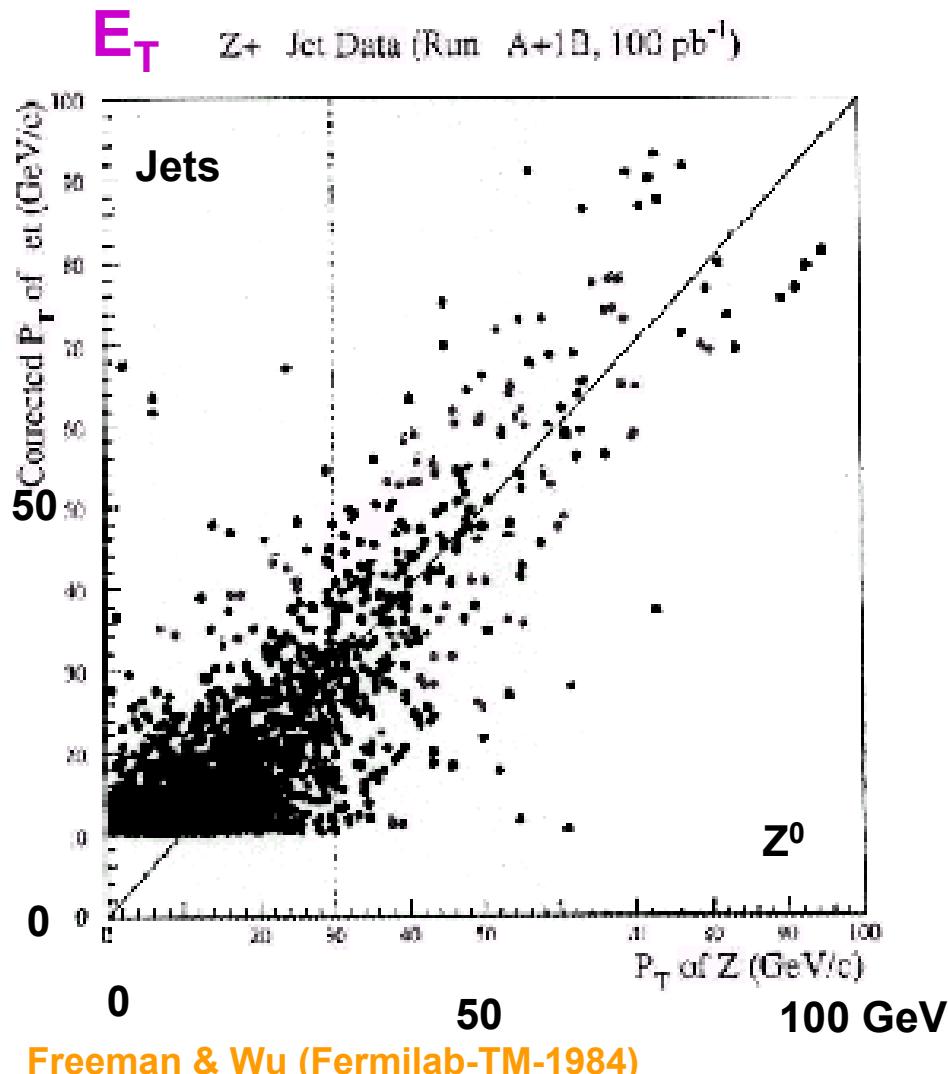
$Et^{\text{jet}2}$ – Et of the second jet

Et^{out} – vector sum of Et outside 3×3 crystals and outside jet

Next step:
 γ -trigger
 π^0 rejection
pile-up



Z (ee,μμ) - jet balancing



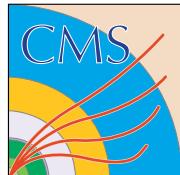
CDF Data (100pb⁻¹) :
energy scale accuracy
to 5% for $E_T > 30\text{GeV}$

CMS:

700k events/month
at 10E33

$|\eta \text{ (lep.)}| < 2.6$
 $E_T(\text{jet}) > 40\text{GeV}$

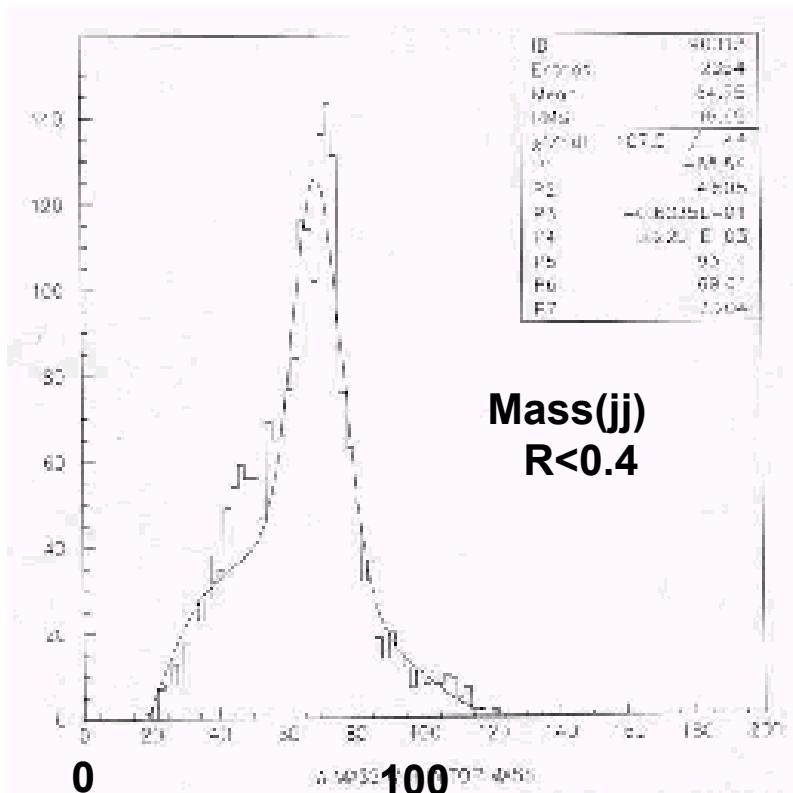
→ New preliminary results
by Anarbay Urkinbaev
in March CMS week.



W(j,j) mass in top decay

Top trigger (1 lepton + jets + 2 b-tags)

- E_T scale by Mass(jj) for W in Top decay.



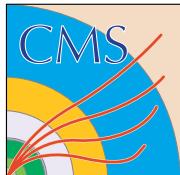
Parameterized simulation

Peak: 69.6 GeV
sigma: 7.2 GeV

45000 events / month
at 10E33
with double b-tagging.

Freeman & Wu (Fermilab-TM-1984)

Need update !



Calibration & Monitoring group

(O.Kodolova)

Test Beam and initial energy scale

- Requirement for beam test / analysis / source

Response Equalization (Uniformity + Dead Ch.)

- Source/min-bias/in-situ

Monitoring (time dependence)

- Source/laser/LED/min-bias/in-situ

Data collection and maintenance

- Data type / Data format / file system / database

Software Tools

- ORCA Interface

JetMET energy scale

- MC study / In-situ calibration

Synchronization

A.Yershov
A.Gribushin
H.Budd, D.Karmgard
(HE) (HO)

A.Krokhotine
K.Teplov
???

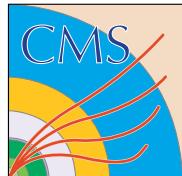
A.Gribushin
A.Yershov
(HB) (HE)(HO)

A.Oulianov
T.Kramer

A.Oulianov
S.Abdullin

I.Vardanyan
A.Kokhotine
P.Hidas
V.Konnopianikov
A.Urkinbaev
R.Vidal,

???



HCAL ORCA Software group

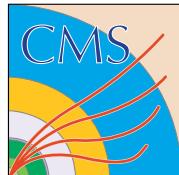
(Salavat Abdullin)

New version

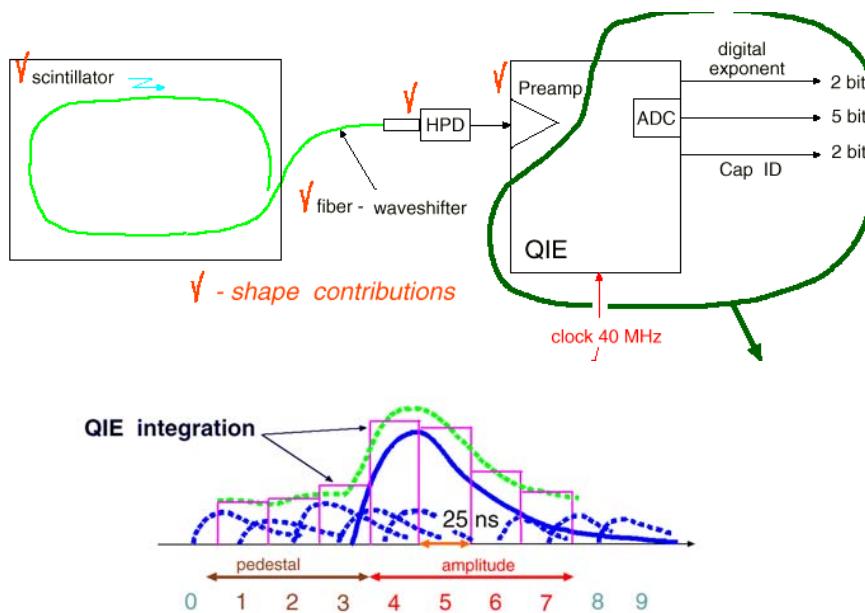
- Released
- “realistic” pulse shape (HPD+QIE+etc.)
- New energy extraction scheme (2 buckets)

Next version

- New coordinator for “Calorimeter” in ORCA
 - Vladimir Litvin (Caltech)
- Usable for both test beam and “CMS”. (?)
- New class structure for whole calorimeter
 - Split pulse shape simulation and energy extraction
- Interface to calibration constants (DB)
 - Eta/phi dependent (channel by channel)
- Requires upgraded simulation
 - Variation of optical fiber length, tile-tile gain variation, etc.



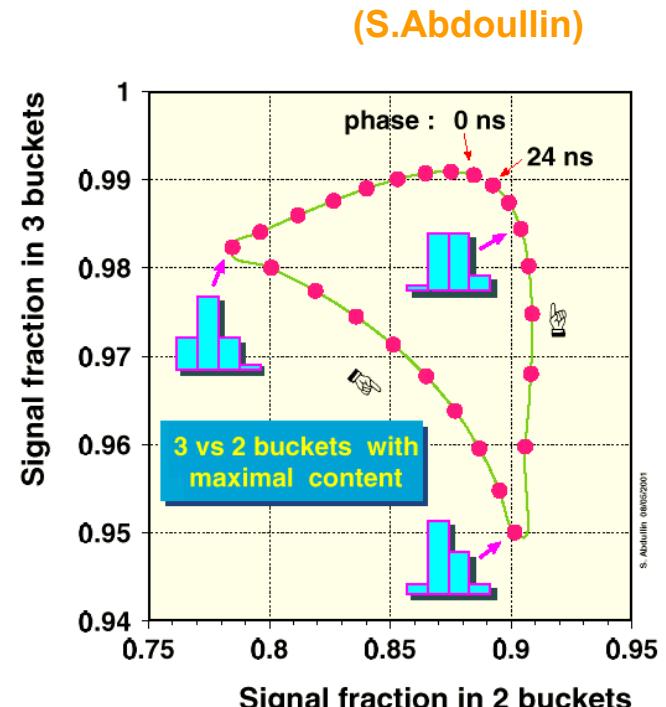
Front end electronics simulation



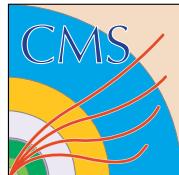
(Original scheme)

$$E = \sum (\text{Signal buckets})_i - \sum (\text{pre buckets})_j / n$$

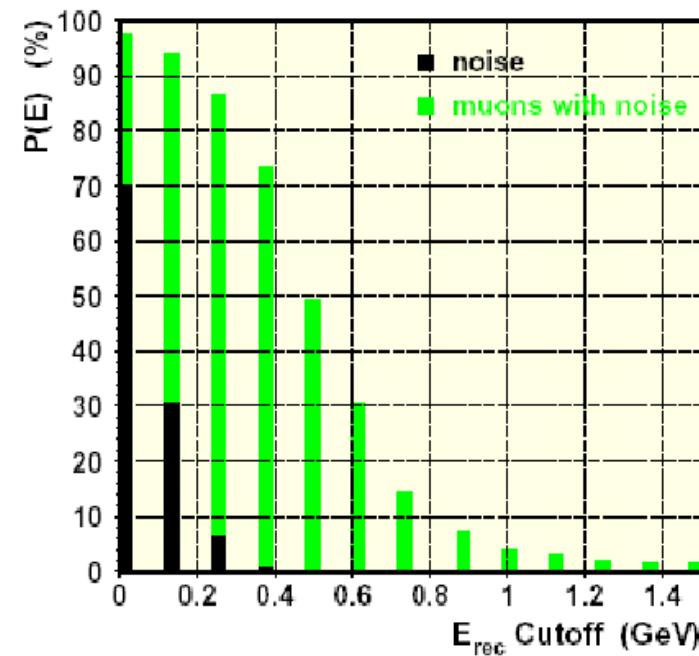
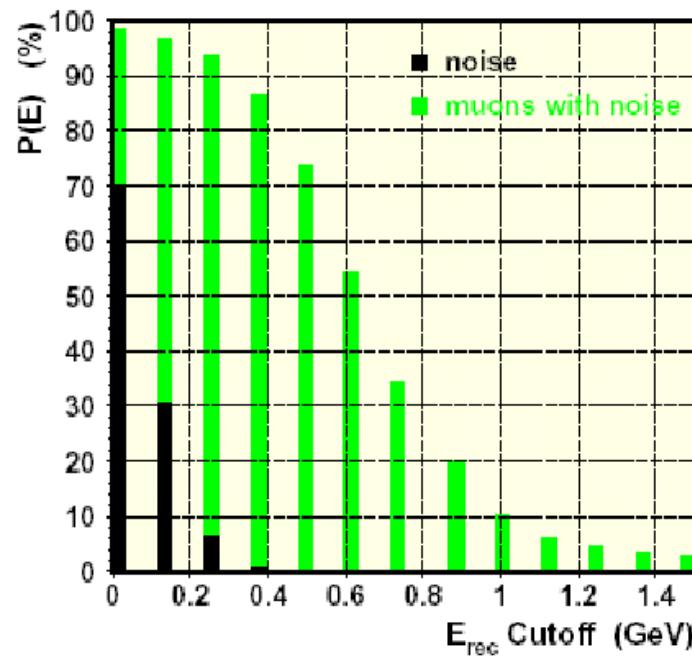
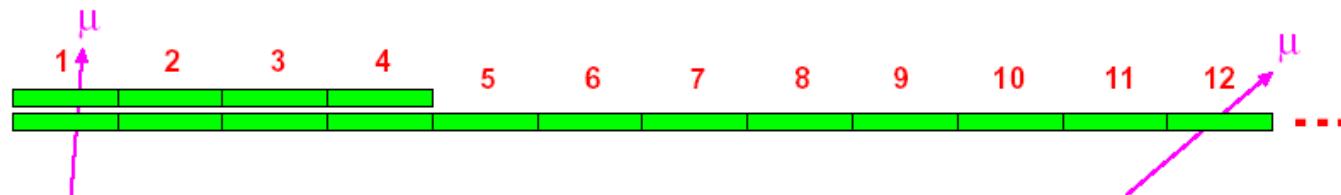
Electronics noise $200\text{MeV}/25\text{nsec}/\text{ch} \rightarrow 500\text{MeV}/(3+3)$ buckets/ch



→ New scheme: 2 buckets for signal separate pedestal events

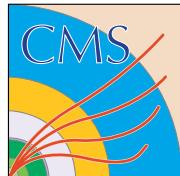


HO for Muon Trigger



At 90% efficiency, have ~5% noise hits. This gives another quiet “plane” to use with RPC.

(S.Abdullin)



Physics objects group – jets/met/ τ

(A.Nikitenko)

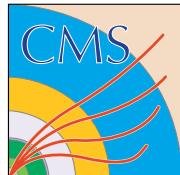
Object reconstruction for HLT and Offline

- Algorithm development
- Software test

Software tools

- Object reconstruction
 - Implementation and/or integration
 - Jets / MET / tau
- Analysis tool
 - Ntuple file maker
 - Root file maker
- Production support
 - Liaison to the central production team

Physics performance study

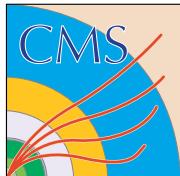


PRS Milestones for DAQ TDR HLT section

L1: Hardware trigger (75kHz max, 25kHz allocated → 1/3 for jetmet)
HLT: Computer trigger (75 Hz max, 25 Hz allocated → 1/3 for jet met)

- ◆ Complete online selection for low-luminosity: Dec 2001
- ◆ Determination of calibration methods and samples: Mar 2002
- ◆ Data rates, data formats, online clustering: Mar 2002
- ◆ CPU analysis for low-luminosity selection: Mar 2002
- ◆ Complete online selection for high-luminosity: Jun 2002
- ◆ Repeat online selection for low-luminosity: Jun 2002
- ◆ CPU analysis of online selection: Jun 2002
- ◆ B physics results ($B_s \rightarrow J/\psi \phi$; $B_s \rightarrow D_s \pi$): Jun 2002
- ◆ DAQ TDR ready (PRS part): Sep 2002
- ◆ L1: DAQ TDR submission (DAQ milestone) Nov 2002

New CMSIM/ORCA production has started !
for 1E34 (and 2E33) with GCALOR
and a new tracker geometry.



HLT

τ -jets / Jets / MET

τ -jets

Narrow jet (similar to electron)

BG: QCD jets

→ Refine narrowness

→ Identify 1/3 charged tracks

L2: ECAL full segmentation

L3: Pixel

$\tau^+ \rightarrow \pi^+ v$	12.5%
$\tau^+ \rightarrow \rho^+ v \rightarrow \pi^+ \pi^0 v$	26%
$\tau^+ \rightarrow a_1 v \rightarrow \pi^+ \pi^0 \pi^0 v$	7.5%

Jets

BG: QCD jets

Fake (+ additional) jets due to pile-up ($E_T < 50\text{GeV}$)

→ Improve energy scale and resolution

→ Remove fakes



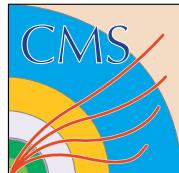
MET

BG: badly measured QCD jets (+ hot/dead cell)

b/c semi-leptonic decays (?)

→ Improve energy scale and resolution

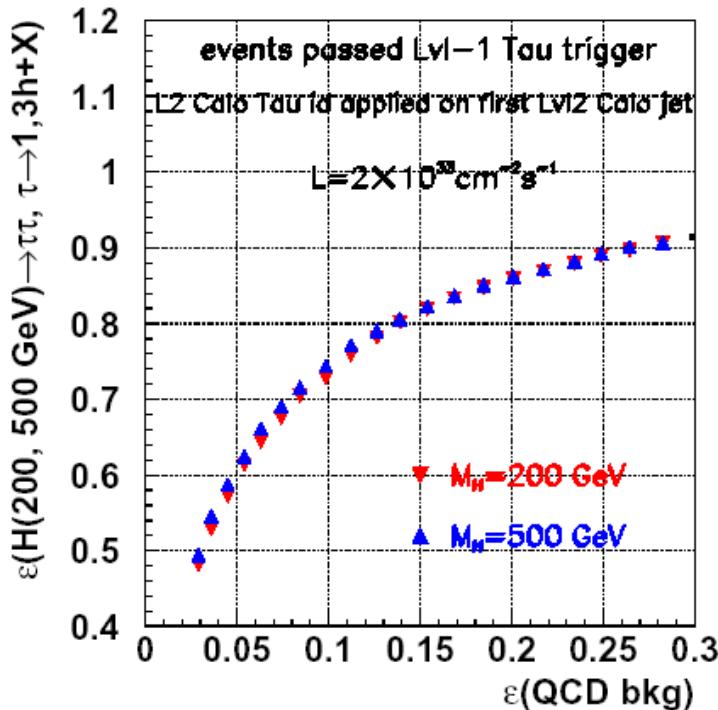
→ remove BG's.



L2 & L3 tau trigger (method 1)

L2

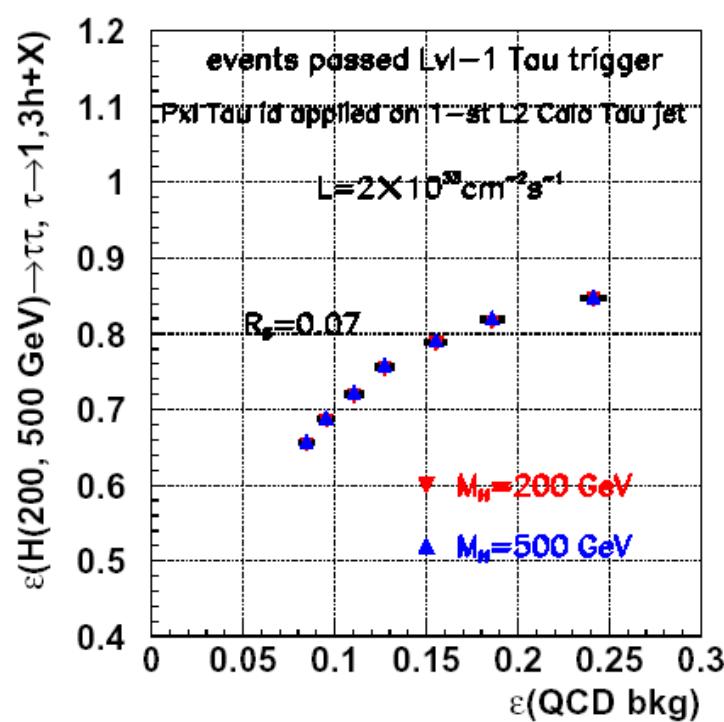
first apply calo id for
1-st L2 Calo Jet



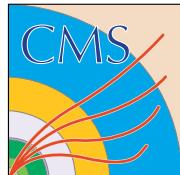
and suppress rate by
factor 5

L3

then apply Pxl id for
1- st L2 Calo Tau Jet

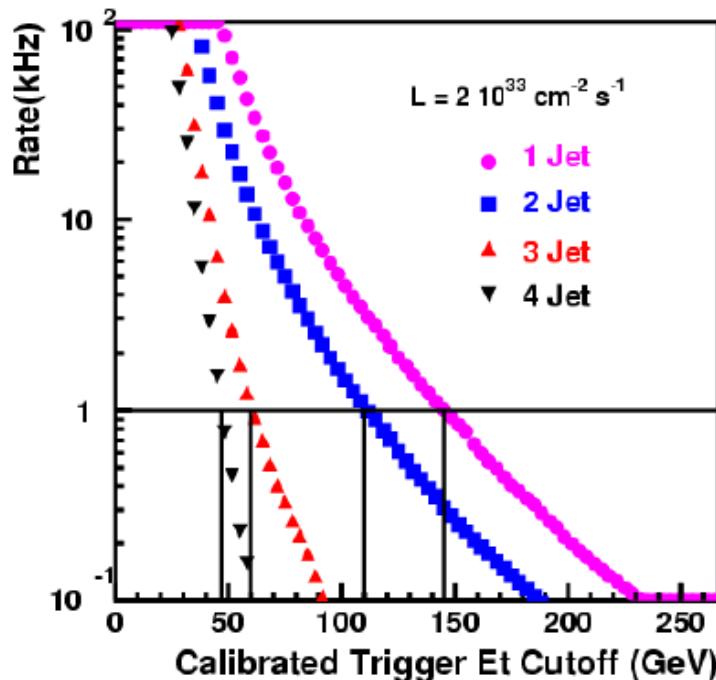


and suppress rate by
factor ~10

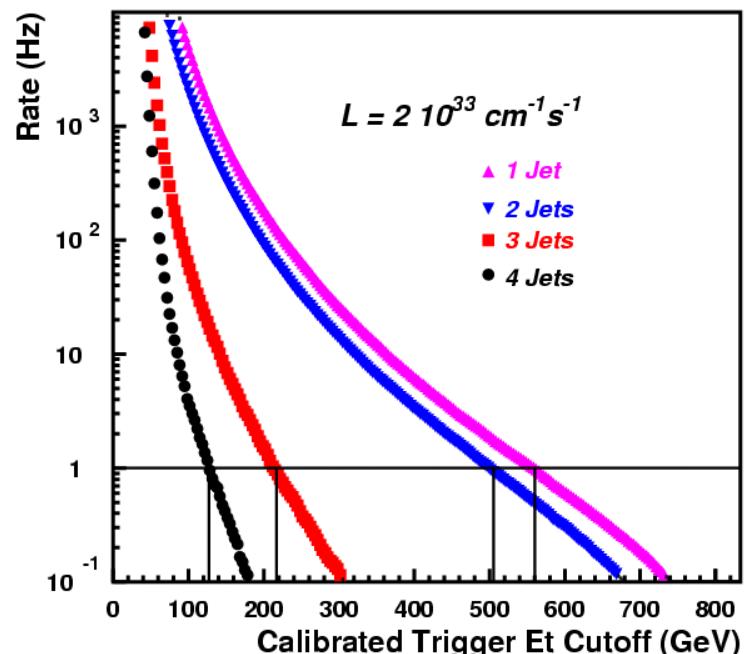


L1 & L2: Jets

L1

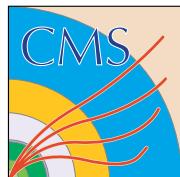


L2



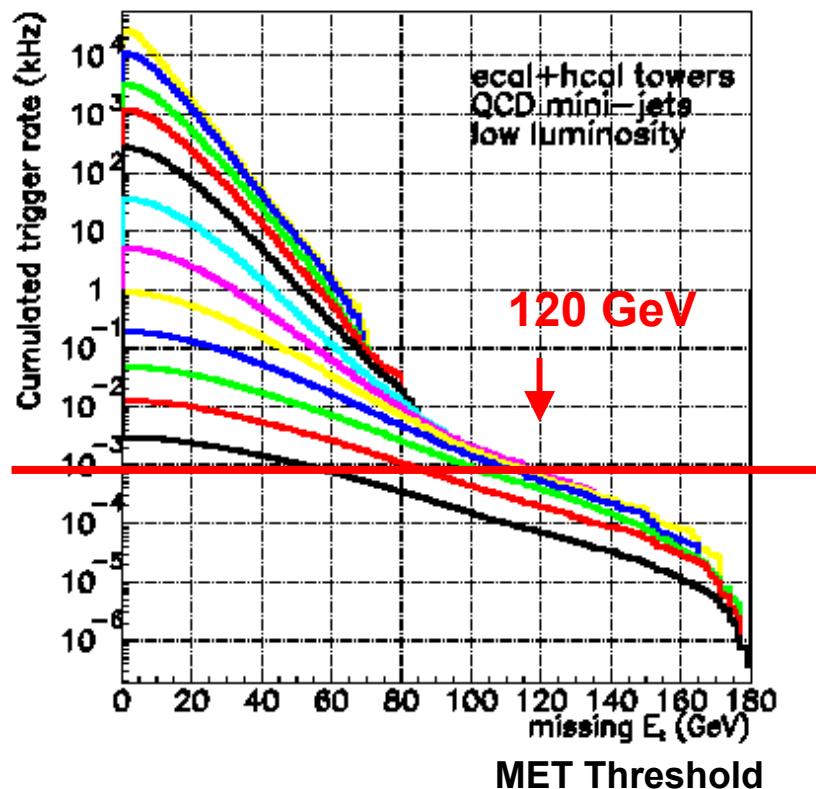
# of jet	L1 (1kHz)	L2 (1Hz)
1	145 GeV	560 GeV
2	110 GeV	505 GeV
3	60 GeV	217 GeV
4	47 GeV	127 GeV

Large QCD
jet rates!

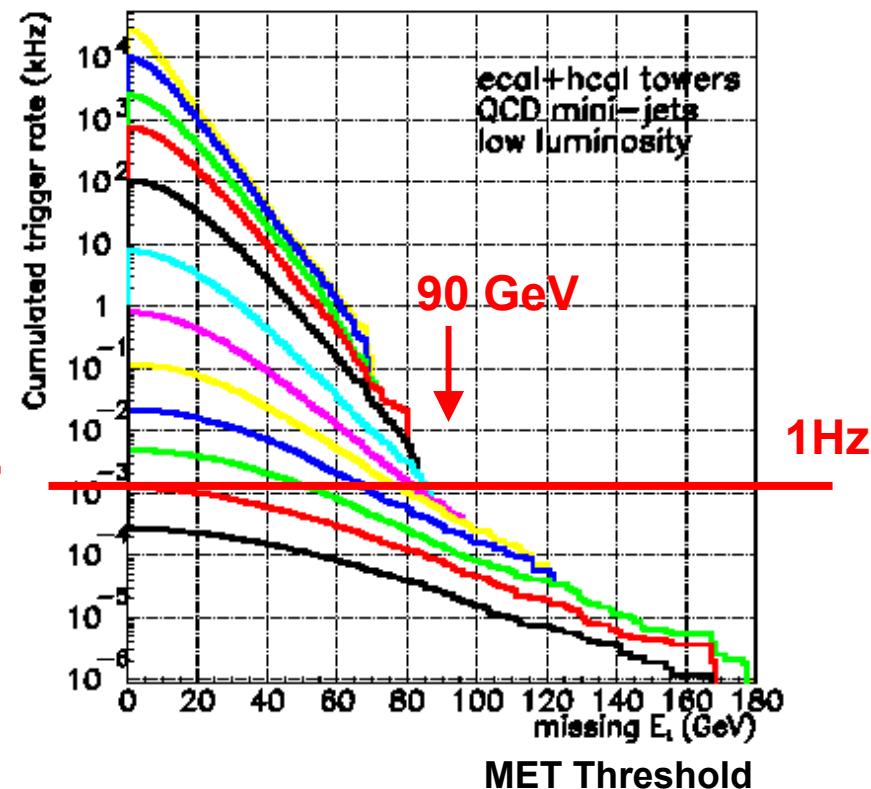


L2 MET

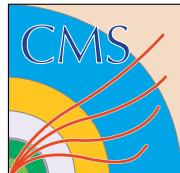
No veto



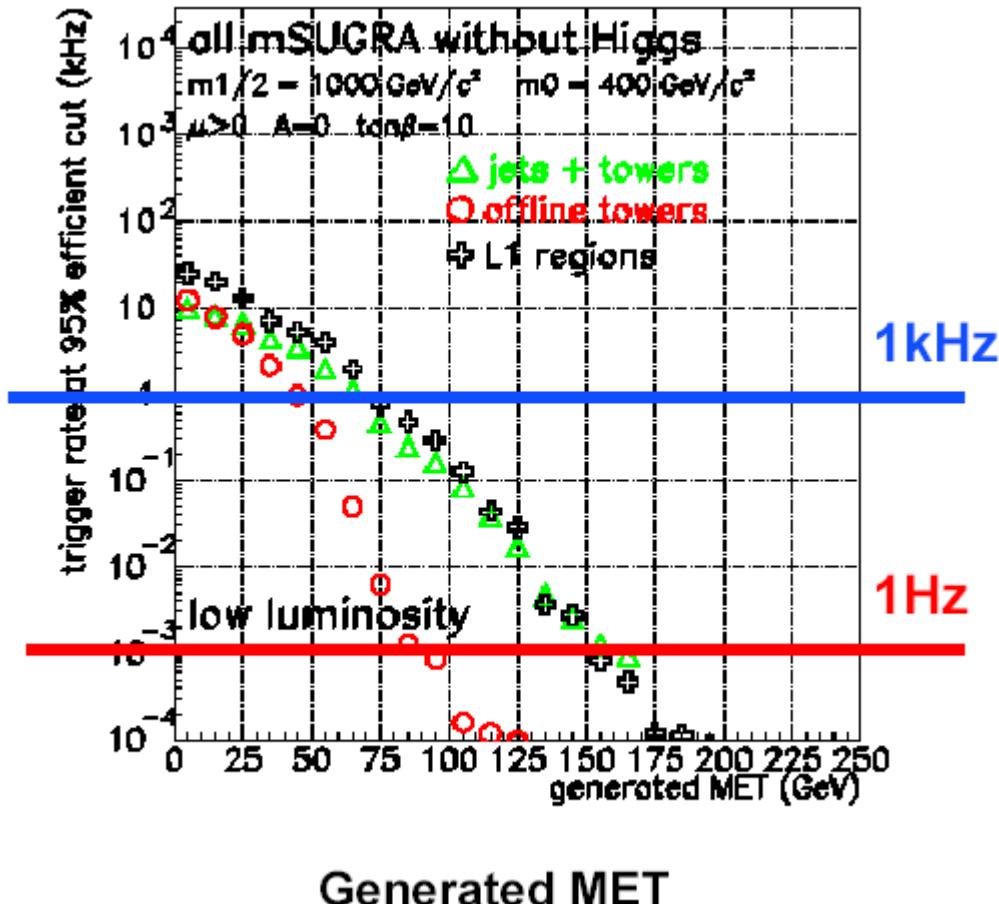
back-to-back jets veto
 $\Delta\phi(1,2) > \pi - 0.5$ (veto)



$\Delta\phi$: angle between 1st and 2nd largest ET jets in transverse plane.
~ 10 reduction with the veto.

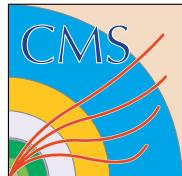


L1 MET vs L2 MET



Trigger rates
with 95% efficiency
for a SUSY sample
as a function of
generated MET

L1 has ~1000 times
higher rate. Why?



List of Physics Channels for HLT performance study

- ◆ WH(115); $H \rightarrow bb$ (but not for “low luminosity” any more)
- ◆ ttH(115); $H \rightarrow bb$
- ◆ $H(115) \rightarrow \gamma\gamma$
- ◆ $H(200) \rightarrow \tau\tau$; subcases:
 - $\tau\tau \rightarrow e+jet$
 - $\tau\tau \rightarrow \mu+jet$
 - $\tau\tau \rightarrow jet+jet$
- ◆ $H^+(200) \rightarrow \tau\nu$
- ◆ tt production; $t \rightarrow \ell \nu b$
- ◆ Inclusive W,Z production; $W \rightarrow (e/\mu)\nu$, $Z \rightarrow (ee/\mu\mu)$
 - Assume: no chance to do $Z \rightarrow \tau\tau$ (confirm...)
- ◆ qqH_{sm}(light); $H_{sm} \rightarrow \tau\tau$ (Nikitenko) done!
- ◆ qqH(130); H Invisible (Nikitenko, Brooke)
- ◆ qqH(120); $H \rightarrow WW^* \rightarrow \ell\ell\nu\nu$ (Zeyrek, Nikitenko)
- ◆ SUSY; jets+ E_t^{miss} (Abdullin)
 - Three “points” in new benchmark space: B,C and E

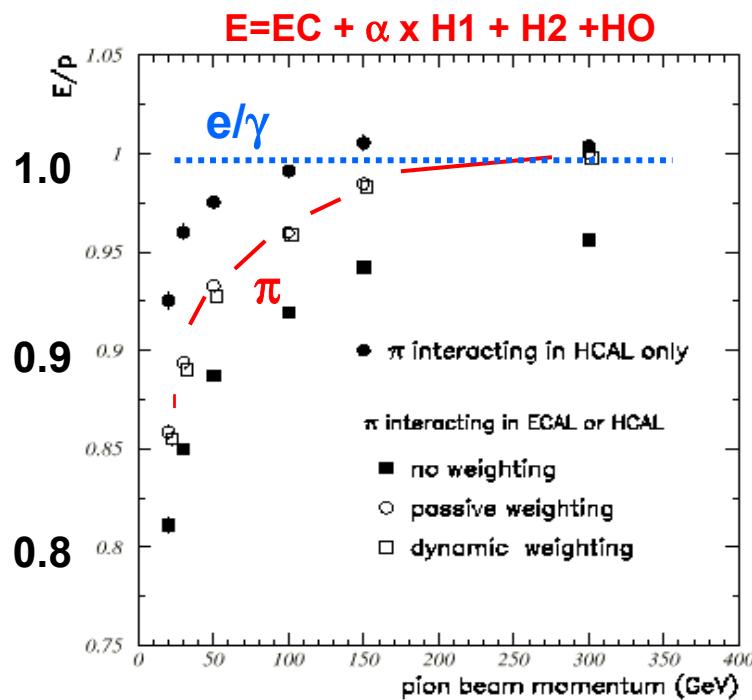


EE vs no EE

e/ π

There will be no endcap ECAL at the beginning of physics run (probably)!

96'H2 Test Beam Data

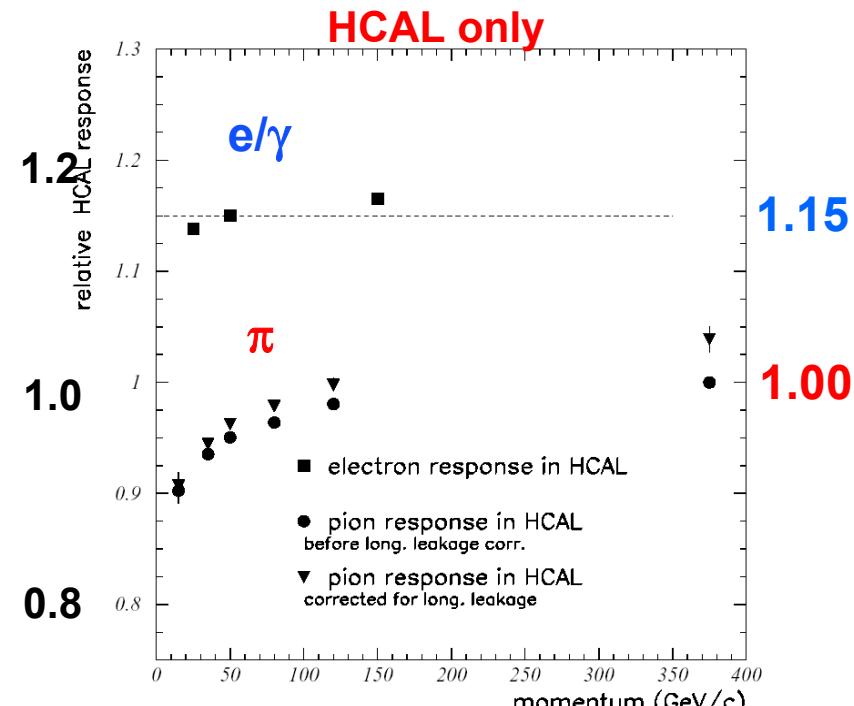


P= 0

200

400GeV

95'H4 Test Beam Data



200
400GeV

1.15

1.00

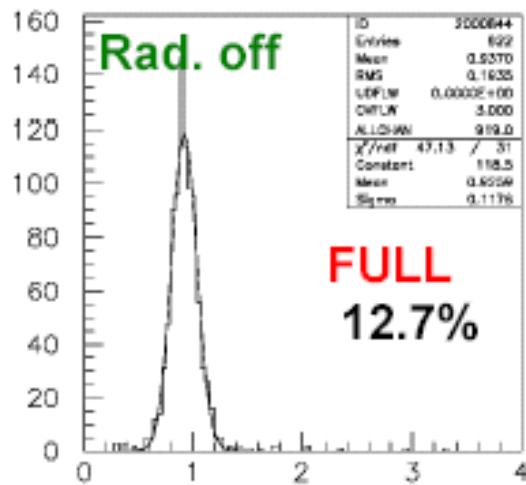
Who wins- resolution or e/pi?



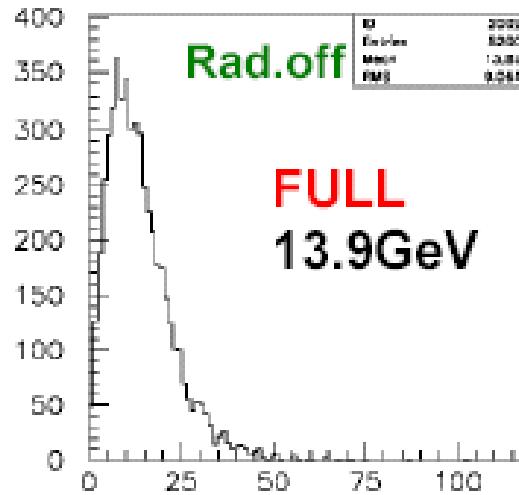
Full Detector vs. no-EE

$Z'(120) \rightarrow \text{jet} + \text{jet}$

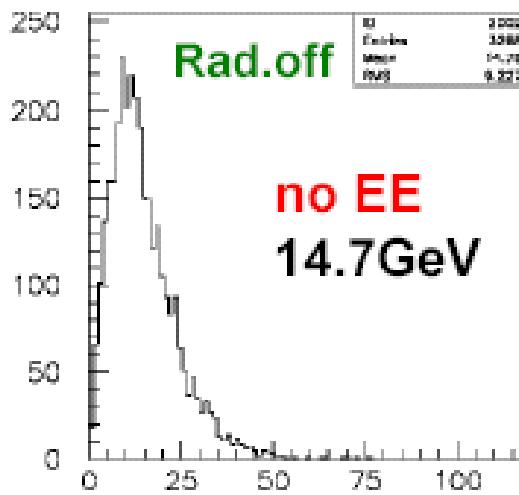
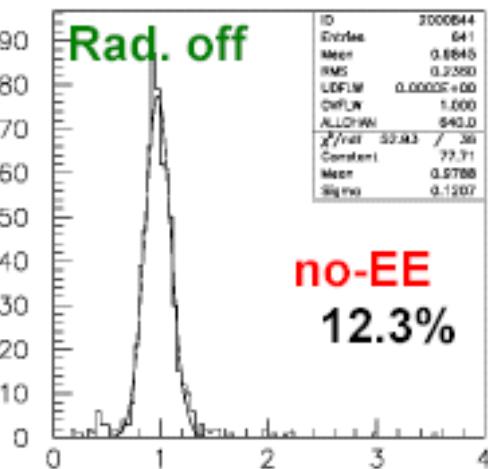
(normalized) Mass



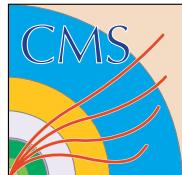
MET



At least one of jets in the endcap region.



No difference for this sample!



ROOT

Event Database

- CMS decided to move from Objectivity to ROOT/IO+ α .

Event Analysis Tool

- Lizard or ROOT
- Current JetMET analysis uses PAW/Ntuple
 - Problem with PAW/ntuple
 - Limited information (because of size limitation)
 - particles, towers, jets, met
 - Macro uses FORTRAN
 - Moving to ROOT
 - Possibility to add more information-
 - Tracks, e/ γ , muons, ...
 - C++ based
 - smaller file size by compression.

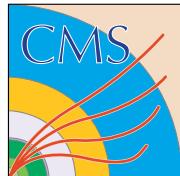
→ Jordan Damgov + Robert Lee, Hans Wenzel, Pal Hidas

- Step 1) Defining ROOT objects.
- Step 2) Implementation



CMS Week

	PRS: HCAL/JetMET	Others
Mon 900-1030		HCAL PM
1100-1800		Plenary Opening
Tue 900-1030	Calib/Monit - simulation work - (Olga)	HCAL I&C, TRIG
1100-1230	Physics Obj (Sasha)	
1400-1600	PRS Muon	DAQ
1600-1800	PRS b/tau	
Wed 900-1000	Subgroup manager reproto (se/sk)	Physics
1030-1230	DCS-PRS joint -calibrarion- (Jim/Olga)	Physics
1400-1600	PRS e/gamma	HCAL Elec/DCS
1600-1800	PRS JetMET (se/sk)	HCAL IB
Thr 830-1230		Plenary
1400-1600	Software (Salavat/Sunanda)	FB/MB/CB
1600-1800	- open for working session -	
Fri 900-1230	Joint with Physics group (Sasha)	
1300-1400	Subgroup manager (closed) (se/sk)	
1400-1800	Joint with Physics group (Sasha)	CB



Summary

Simulation

- Verify Simulation
- Transition to OSCAR/GEANT4
- Test beam simulation

Calibration & Monitoring

- Improvement for energy scale and resolution.
- Scenario from construction to in-situ calibration.
 - Use test beam as a prototype of full system.
 - Need to understand requirements for trigger and data streaming of in-situ calibration sample.

HCAL Code in ORCA

- Readout simulation and energy extraction: updated.

Physics Objects

- HLT for 2E33 is done. E34 is next → Pile-up suppression will be issue.
- Implementation jet energy correction algorithm in ORCA.
- Investigation of jet/MET algorithms other than simple cone algorithm.

Physics Analysis

- Analysis of more physics channels is desirable.